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14. ABSTRACT
This document describes the procedures for determining the coincidence window of a tank fire control system. The coincidence window is defined as the limits around exact sight/gun alignment within which the gun is permitted to fire (omitting the offsets imposed by a ballistic solution). Typically, a combat vehicle implements the coincidence windows based on the current alignment (static) and in some cases additionally the future alignment (dynamic) of the sight and gun. Procedures for determining coincidence window performance (with and without gunner input) against the tank's coincidence window and a standard test window of 0.3 mrad x 0.3 mrad are included.

The reader is referred to TOP 3-2-836 (0) Combat Vehicle Fire Control Systems - Overview Document or International Test Operations Procedure (ITOP) 3-2-836 (0) Combat Vehicle Fire Control Systems - Overview Document.

15. SUBJECT TERMS

Drift	Drift Rate	Angular Displacement	Gun	Turret
Combat Vehicle	Main Battle Tank	Fire Control System	Line of Sight	

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure (TOP) 3-2-836 (2.2.3) 09 November 2009
DTIC AD No:

COMBAT VEHICLE FIRE CONTROL SYSTEMS

COINCIDENCE

This TOP supersedes ITOP 3-2-836 (2.2.3), dated 29 June 1995.

1. SCOPE.

This document describes the procedures for determining the coincidence window of a combat vehicle fire control system. The coincidence window is defined as the limits around exact sight/gun alignment within which the gun is permitted to fire (omitting the offsets imposed by a ballistic solution). Typically a combat vehicle implements the coincidence windows based on the current alignment (static) and in some cases additionally the future alignment (dynamic) of the sight and gun. Procedures for determining coincidence window performance (with and without gunner input) against the tank's coincidence window and a standard test window of 0.3 mrad x 0.3 mrad are included.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

2.1.1 Gridboard or Collimator.

A gridboard or collimator that will permit the location of aiming points within 0.05 mrad.

2.1.2 Coincidence Test Courses.

The courses listed below are typical for determining the percentage of time that a sight and gun are in coincidence.

a. Level Hard Surface. A straight and level hard surface course 200 meters in length made of concrete or pavement closing with the target.

b. Bump Course. A series of trapezoidal wooden, concrete, or metal blocks, that are located at specified positions on a straight and otherwise level road in a direct line with a stationary target. The layout of the recommended elevation bump course is shown in Appendix A, Figure A-1. Additional bump courses may be used according to the performance of the sight/gun system. Courses used must be documented.

c. Sinuous Course. A level hard surface with a series of turns and straight-line segments that alternately cross the line of approach to a stationary target. The layouts of the recommended sinuous courses are shown in Appendix A, Figure A-4.

d. Gently Rolling Terrain (GRT). A straight, natural (earthen), rolling terrain course 200 meters in length, closing with the target.

2.1.2 Targets.

Targets, if required, must be of appropriate size and marked with an appropriate aim point (e.g., light contrast for daylight sight, heat source for thermal sight).

2.2 Instrumentation.

DEVICES FOR MEASURING	Permissible Error of Measurement*
Angular deviation of the line of sight (LOS) of the sight reticle and the LOS of the gun	0.05 mrad **
Status of coincidence window inhibit for the main gun firing circuit	Not applicable
Synchro error signals between gun LOS and sight LOS (optional)	0.05 mrad
Time base for all events	1 msec

*The permissible error of measurement is the two standard deviation value for normally distributed instrumentation calibration data. Thus, 95 percent of all instrumentation calibration data readings will fall within two standard deviations from the known calibration value.

** The preferred unit for angular measurement is the radian. Milliradian (mil) or degree units may be used when required; units of measure must be identified.

3. REQUIRED TEST CONDITIONS.

3.1 Inspection and Servicing.

a. Ensure all required system maintenance is performed in accordance with applicable Technical Manuals, Lubrication Orders, or other guidance documents.

b. Ensure that:

(1) All operating systems are up to proper speeds (gyroscopes), and all systems are at normal operating temperatures (electro-optical and mechanical).

(2) The torque friction and backlash at the turret and gun coupling locations are within specified values. If the torque friction and backlash are within specification but not optimal, do not optimize. The test should be conducted within the specification range.

(3) The gun balance complies with specified values as applicable. Provide weight compensation for any installed instrumentation to maintain proper balance as necessary.

3.2 Stowage.

a. Stow the test vehicle with the required complement of ammunition (actual or simulated) and all items of on-equipment materiel (actual or simulated) to provide the moment of inertia and center of gravity (CG) of a combat- loaded vehicle.

b. Attach all equipment (or simulant) to the gun that is normally attached during combat, e.g., searchlight, telescope, coaxial machinegun, machinegun ammunition belt, ballistic shield.

c. Load a dummy round of ammunition, simulating the primary round carried by the vehicle, in the gun during all nonfiring stabilization system tests.

3.3 Safety.

Safety procedures pertinent to the test area and test vehicle should be adhered to at all times. The following procedures should be considered:

a. Inspect the system for safety hazards before testing, and continually monitor the system for hazards during testing.

b. Use experienced vehicle operators who have received training on the test system.

c. Ensure that adequate protective clothing is worn, e.g., helmets, safety shoes, eye and ear protection.

4. TEST PROCEDURES.

4.1 Determination of Static Coincidence Window.

The following procedures are to determine the size of a tank's coincidence window under static conditions. If coincidence window is condition-dependent (e.g., range, ammunition type, etc.), perform sufficient tests to assess the performance for each condition.

a. Position the tank on a level surface.

b. Boresight the tank at a specified range.

c. Monitor the tank fire control system to determine if the main gun firing circuit is inhibited. This can be done by monitoring the appropriate signals in the fire control computer. If available from the system, the synchro error signals between the sight reticle LOS and gun LOS should be collected.

d. Implement a complete ballistic solution for a specific ammunition type at a specified range. Ensure that the sight reticle LOS and gun LOS are properly positioned. At this time, the main gun firing circuit should not be inhibited.

e. Determine the relative positions of the sight reticle LOS and the gun LOS using gridboard(s) or a collimator.

f. Very slowly drive either the sight reticle LOS or the gun LOS to the right without moving the other. This can be done by using a feature that is unique to the main battle tank under test or by inputting positioning commands to the sight or gun synchro from an independent signal generator.

g. Monitor the tank fire control system for an inhibited main gun firing circuit. Stop moving the sight reticle LOS or gun LOS when the main gun firing circuit is inhibited. Determine, from the gridboard(s)/collimator, how far the sight reticle LOS/gun LOS has moved.

h. Repeat procedures 4.1f and 4.1g ten times. Determine a mean and variance for this coincidence window limit.

i. Repeat procedures 4.1a through 4.1h moving the sight reticle LOS/gun LOS up, down, and left. This will establish the entire coincidence window.

4.2 Coincidence Window Performance.

The following procedures are to determine the coincidence window performance under dynamic conditions. If coincidence window is condition-dependent (e.g., range, ammunition type, etc.), perform sufficient tests to assess the performance for each condition.

a. Position the vehicle at the beginning of the test course. Tests are conducted on courses that predominately emphasize requirements for one axis (e.g., azimuth or elevation) at a time.

(1) A straight and level hard surface course is used to determine a baseline for the system under test. This course provides low level elevation and azimuth disturbances. This is a required test course.

(2) The bump course (Appendix A) provides for a wide range of elevation disturbances.

(3) The sinuous courses (Appendix A) provide for a wide range of azimuth disturbances based on course dimensions and vehicle speed.

(4) The gently rolling terrain course represents a realistic cross-country test terrain. This course favors an operational test environment as opposed to a standard repeatable test course.

b. Monitor the tank fire control system to determine if the main firing circuit is inhibited. This can be done by monitoring the appropriate signals in the fire control computer.

If the coincidence window status is not available from the fire control system, an alternate way to qualify fire inhibit is to record trigger pulls and fire pulse. The gunner should engage the trigger when the gunner feels there is a good aim on target. The time required for the fire pulse to reach the firing pin is indicative of the fire inhibit performance. It should be noted that even under ideal performance there will be some nominal delay between trigger pull and fire pulse.

c. Implement a complete ballistic solution for a specific ammunition type at a specified range. Ensure that the sight reticle LOS and gun LOS are properly positioned. At this time, the main gun firing circuit should not be inhibited.

d. Prior to initializing the test run, any system drift should be neutralized or minimized by utilization of any system-drift (null) controls.

e. With the system fully stabilized, the test vehicle is driven on the selected course in speed increments (e.g., 5 km/hr) up to maximum safe speed. Resonance speeds should be tested; instrumentation limitations (i.e., frequency response) may require analysis of system synchro signals.

f. The gunner aims on the selected target and fully activates the fire control system. Testing is conducted without gunner input.

g. Continuously monitor the tank fire control system to determine if the main gun firing circuit is inhibited.

h. Record sight reticle LOS and gun LOS position at the target.

i. Record main gun firing circuit inhibit versus time.

j. If available from the fire control system, the synchro error signals between the sight reticle LOS and gun LOS should be collected.

k. Testing should be conducted using a variety of range inputs, vehicle speeds, and on various test courses. Table 1 shows a sample set of test occasions. Each occasion should be conducted once without gunner input and once with gunner input. Three runs are to be completed for each test occasion.

TABLE 1. COINCIDENCE WINDOW PERFORMANCE
TEST OCCASIONS

Occasion	Stabilization Course Type	Tank to Target Orientation, deg[a]	Range to Target, m[b]	Tank Speed, km/hr
1	LHS[c]	0	1500	15
2		15	1500	15
3		0	1500	30
4	Bump	0	1500	15
5		0	2500	15
6		15	1500	15
7	Sinuous B	0	1500	15
8		0	2500	15

[a]0^{o} is defined as the Y or range axis of the test course; rotations of 15^{o} may be clockwise or counterclockwise.
[b]Nominal range to target.
[c]Level hard surface.

5. DATA REQUIRED.

5.1 Determination of Static Coincidence Window.

a. Description of instrumentation used, system configuration, and operating mode.

b. Inputs to fire control computer.

c. Azimuth and elevation coincidence window limits.

d. If available from the system, the synchro error signals between the sight reticle LOS and gun LOS should be collected. These data are optional, but are useful for comparison with the instrumentation data.

5.2 Coincidence Window Performance.

a. Description of test courses, instrumentation used and system configuration or operating mode.

b. Inputs to fire control computer.

c. Main gun firing circuit inhibited versus time.

d. Sight reticle LOS and gun LOS position at the target versus time.

e. Time base for all data.

f. If available from the system, the synchro error signals between the sight reticle LOS and gun LOS should be collected. These data are optional, but are useful for comparison with the instrumentation data.

6. PRESENTATION OF DATA.

6.1 Determination of Static Coincidence Window.

a. Tabulate data to give:

(1) Trial number.

(2) Inputs to tank fire control computer.

(3) Direction of sight reticle LOS/gun LOS movement.

(4) Coincidence window limit determined during test.

(5) If available from the system, the synchro error signals between the sight reticle LOS and gun LOS.

b. For each direction of sight reticle LOS/gun LOS movement, the data should be summarized by computing a mean value and variance.

6.2 Coincidence Window Performance.

An overview of the tank's coincidence logic will be presented in the case of a dynamic coincidence window (e.g., coincidence logic is affected by LOS rates).

a. For each test run tabulate the following:

(1) Trial number.

(2) Inputs to tank fire control computer.

(3) Test course used.

(4) Performance according to tank's coincidence window.

(a) Percentage of time the sight reticle LOS and gun LOS were within the azimuth coincidence window limits.

(b) Percentage of time the sight reticle LOS and gun LOS were within the elevation coincidence window limits.

(c) Percentage of time the sight reticle LOS and gun LOS were within the azimuth and elevation coincidence window limits.

(d) A histogram of non-coincidence times with marked 85 percent value (Figure 1).

(5) Performance according to standard test coincidence window (0.3 x 0.3 mrad).

(a) Percentage of time the sight reticle LOS and gun LOS were within the azimuth coincidence window limits.

(b) Percentage of time the sight reticle LOS and gun LOS were within the elevation coincidence window limits.

(c) Percentage of time the sight reticle LOS and gun LOS were within the azimuth and elevation coincidence window limits.

(d) A histogram of non-coincidence times with marked 85 percent value (Figure 1).

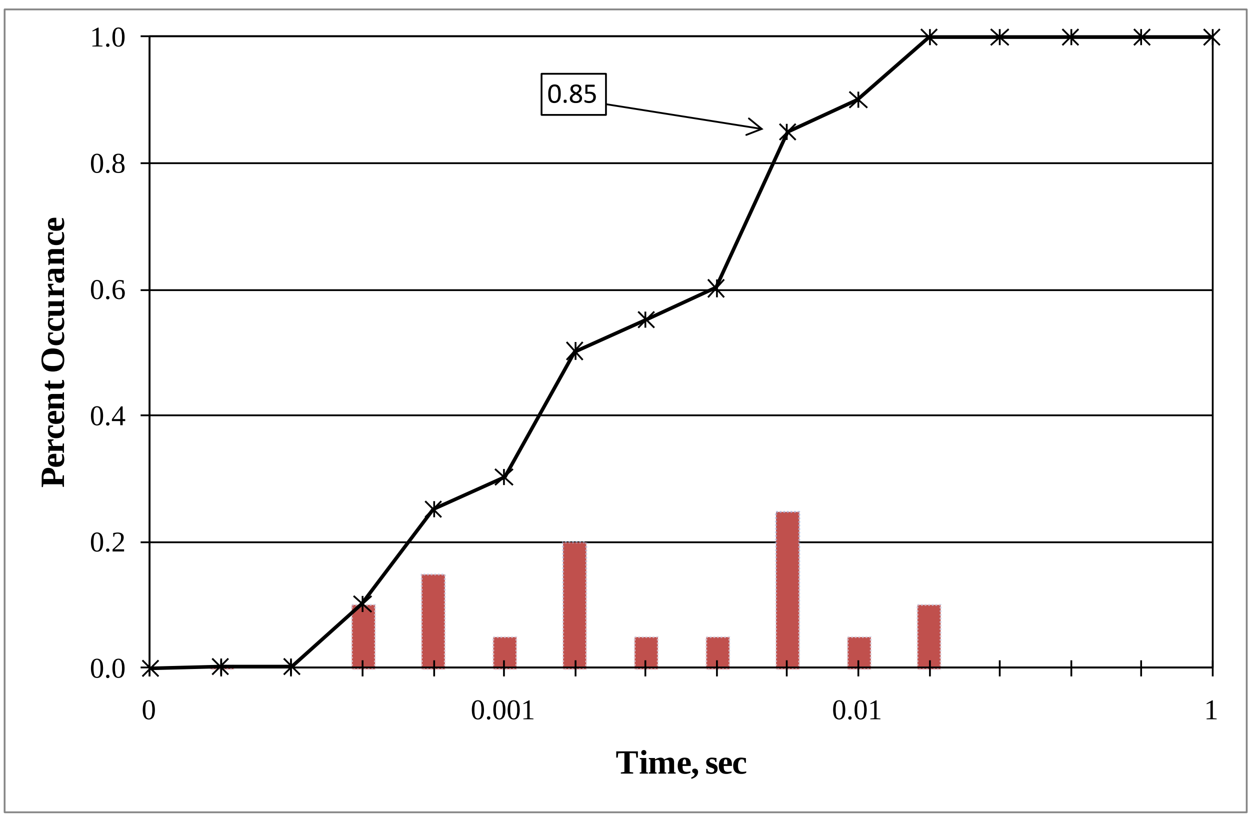

Figure 1. Histogram of non-coincidence times.

b. For each test run plot the following:

(1) The difference between the sight reticle LOS position and gun LOS position at the target versus time. The difference must be adjusted to remove the effects of the implemented ballistic solution. Also, mark the tank's internal and standard test coincidence windows on plots.

(2) Coincidence (when the sight reticle LOS and gun LOS are within the coincidence window limits) versus time for both the tank's internal and standard test coincidence window.

(3) The synchro error between the sight reticle LOS and gun LOS, if obtained during test. These data are optional.

APPENDIX A. COINCIDENCE TEST COURSE LAYOUTS

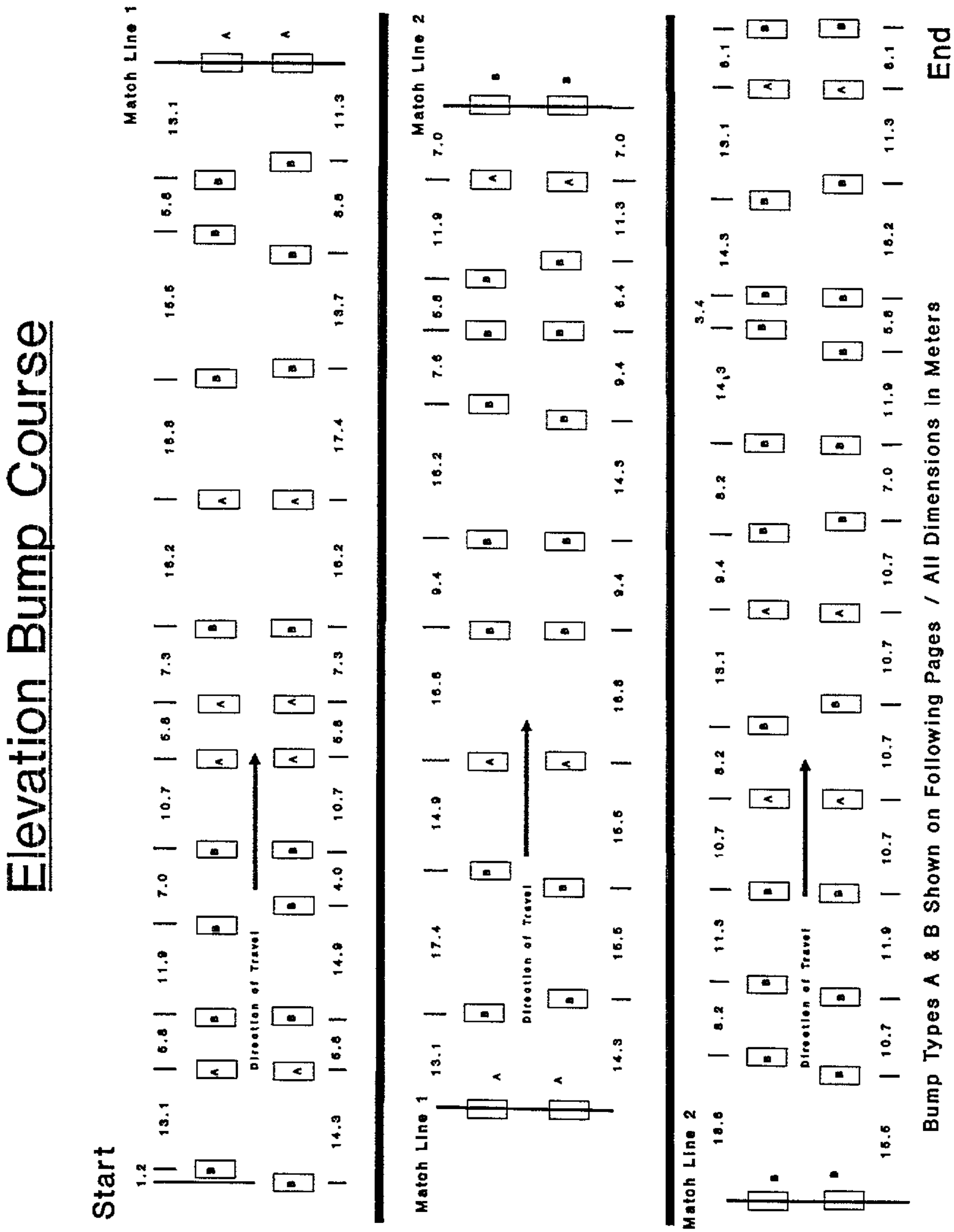

Figure A-1. Elevation bump course.

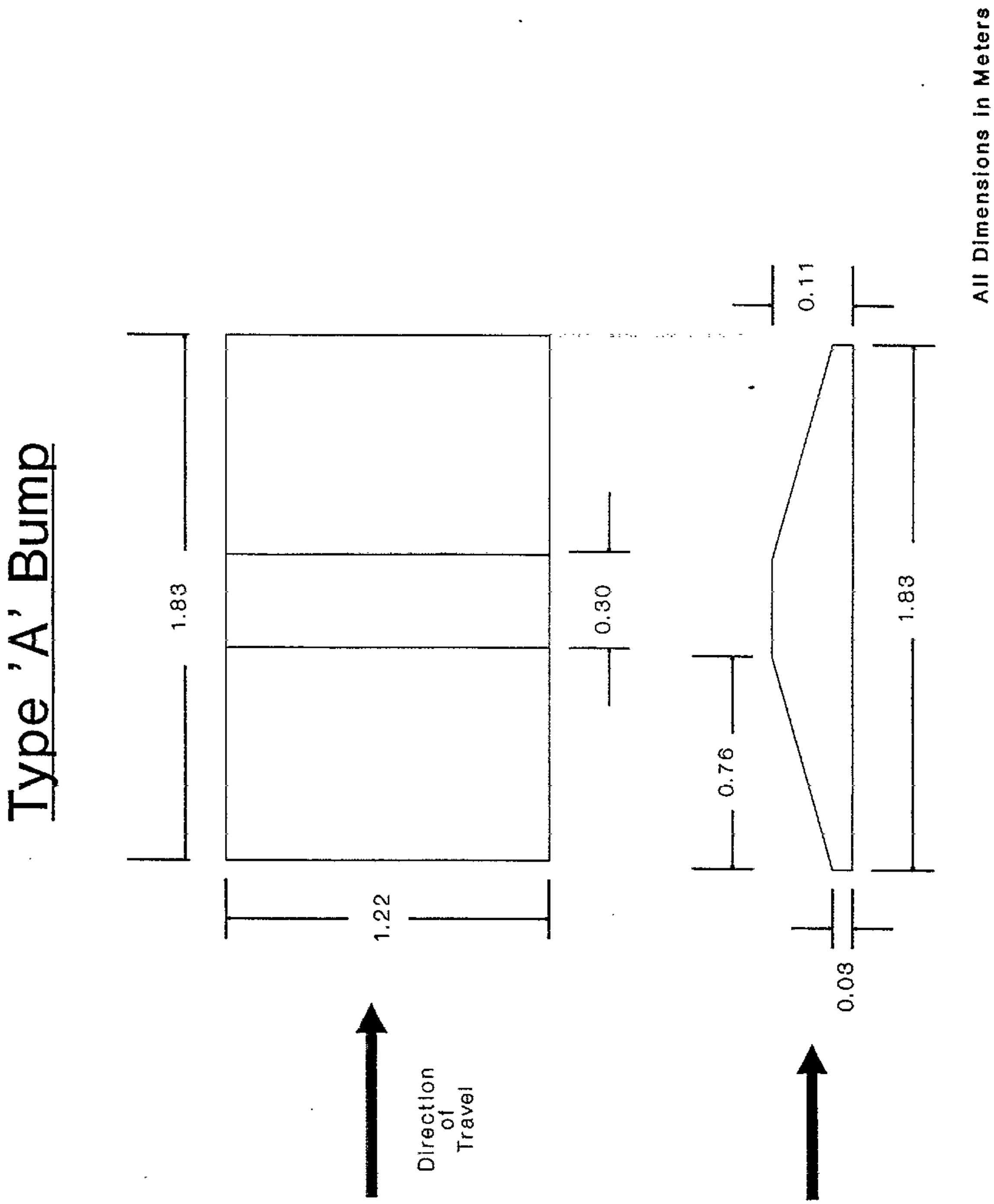

Figure A-2. Type A bump..

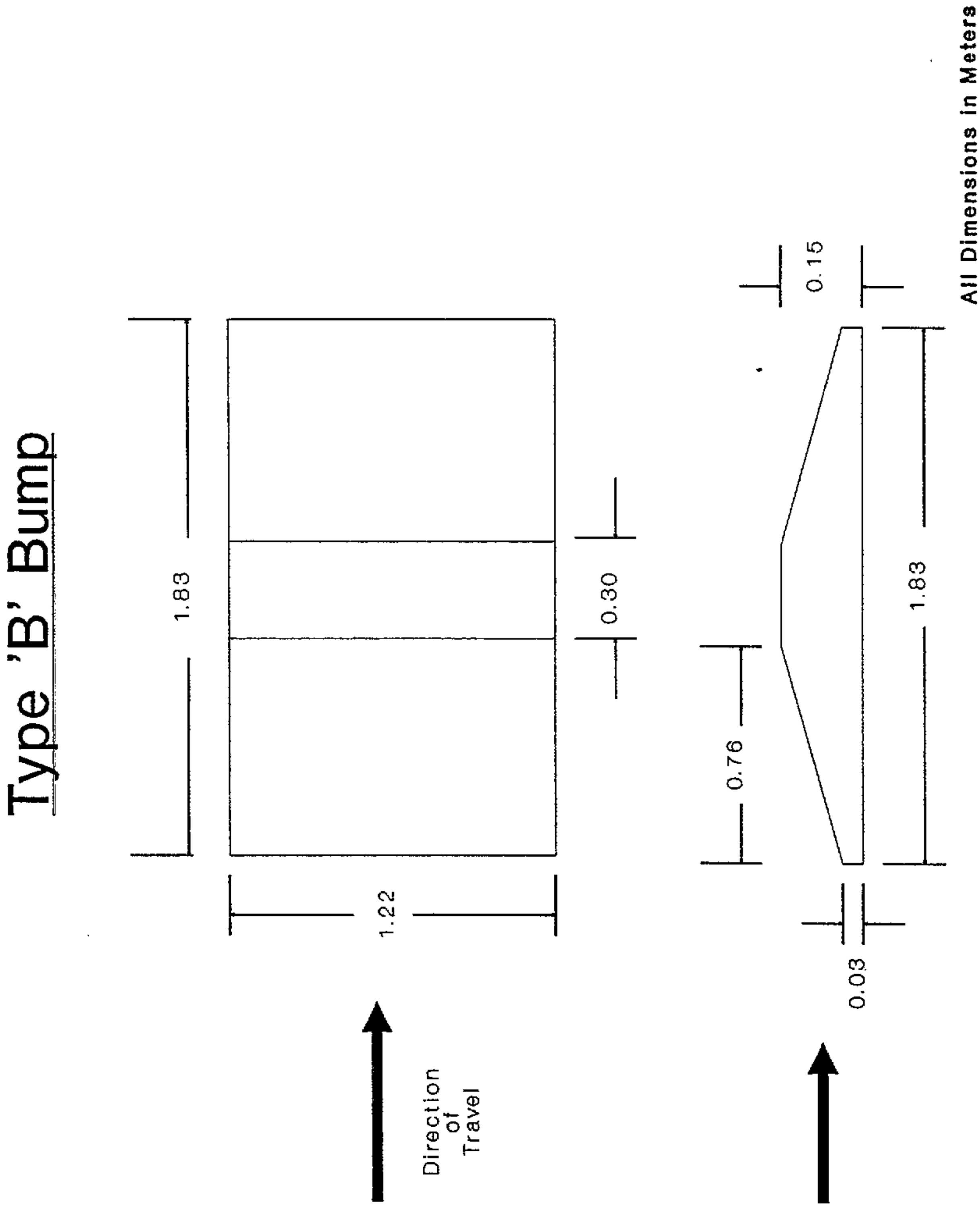

Figure A-3. Type B bump..

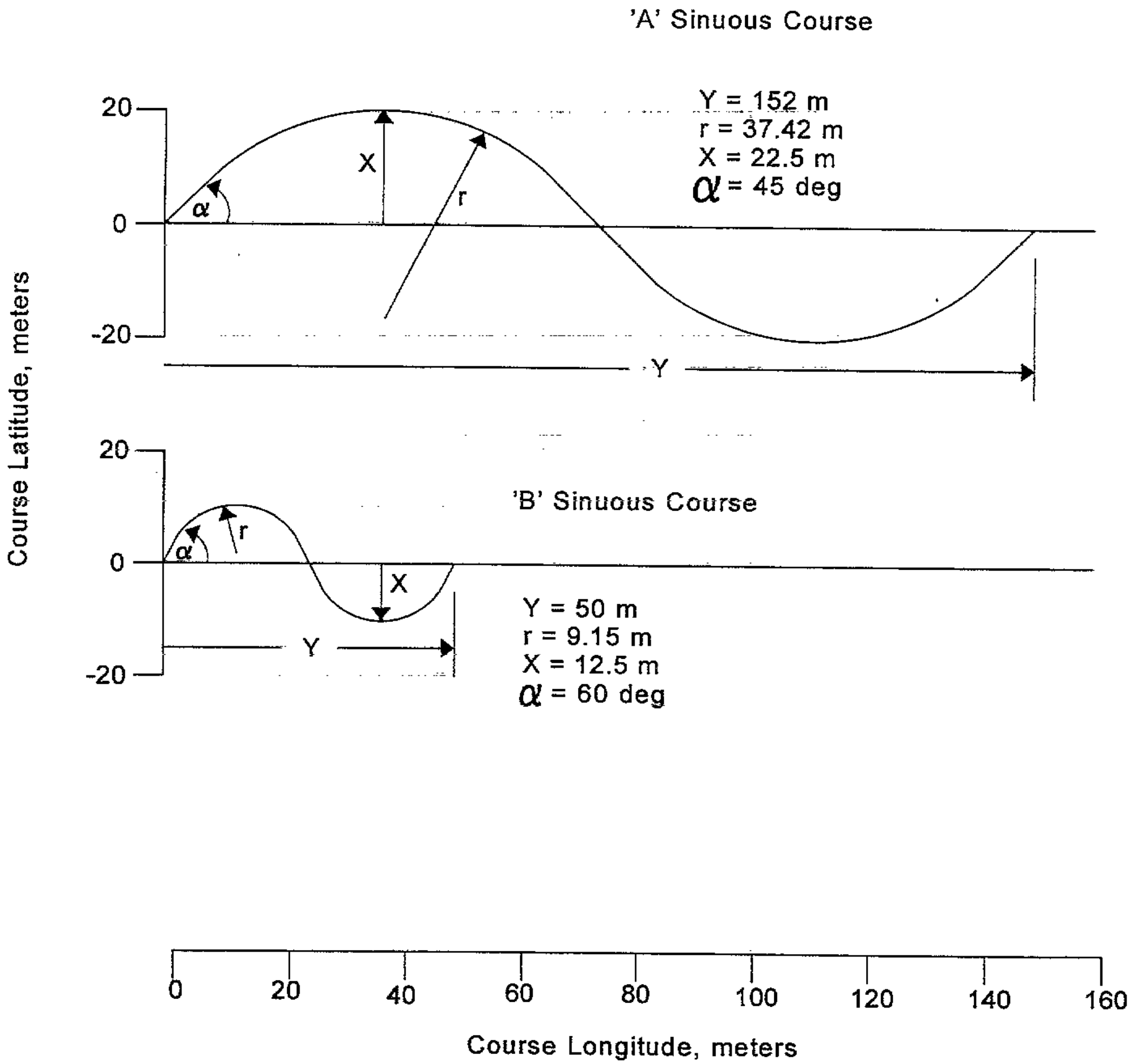

Figure A-4. Sinuous A and B course layouts.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: US Army Aberdeen Test Center (TEDT-AT-ADF), 400 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Informtion Center, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.